LOSS MANAGEMENT SERVICES, INC.
Digital Eye-Witness Systems
MACBOX™

EDR Working Group Meeting Washington, DC, June 7th, 2000

LMS Representation: Richard Pandolfi, President, Andrew W. Mackevicus, VP of Product Development and Dr. Robert McElroy, VP of Engineering

<u>Introduction:</u>

Andrew W. Mackevicus

Loss Management Services, Inc. (LMS) is dedicated to the development of EDR technology for the surface transportation environment.

Product:

Richard Pandolfi

MACBOX:

(Mobile Accident/Acceleration Camera) Box is equipped with a ruggedized CPU that will enable the capturing of an event (pre-during-post), along with other triggers, which will up link the 'driver's eye-view' visual imaging to a LMS repository. The data is then stored for immediate or future use. Other previously identified data can also be triggered and stored within the software package (i.e., speed, breaking, …).

Beta Test Sites:

Dr Robert McElroy

LMS with augment the sites with its ***MACBOX*** technology at both Georgia Tech (GT) and Florida Atlantic University (FAU). Detail discussions from each of the Universities representatives will be presented at this meeting.

Application:

Dr Robert McElroy

Immediate applications in Commercial Transportation: Bus, Truck, taxi and limousines, livery, car rental companies, and Private Passenger Transportation (PPT) for "high risk" drivers.

Benefit:

Andrew Mackevicus & Dr Robert McElroy

Assist in controlling insurance claim litigation, frivolous and fraudulent claims, assist in emergency response time and proper deployment of emergency equipment, proper emergency trauma assessment, controlling youthful drivers and assist elderly drivers, rerouting traffic accident situations with link of intelligent highways, assist insurance industry and law enforcement with a cost effective way to determine fault and liability, assist governmental bodies with timely and cost effective roadway/signage/environmental/climate assessment on real time crash events, stop aggressive driving, data linkage with NHTSA for statistical purposes, assigning driver responsibility and to accurately assess fault of driver and/or auto manufacturer.

MACBOX presents objectivity where there once was none.

Quality of Life Issues:

Andrew Mackevicus

LMS sees the responsibility and the obligation of ***every*** driver on our roadways to be vigilant, as we now face highway incidents at epidemic proportions. With the ***MACBOX***, LMS can achieve its ultimate goal – highway safety through EDR technology.

Future:

LMS invasions many applications with the ***MACBOX*** both for the surface transportation fleet management and PPT areas. With the advantage of the visual, roadway safety and increased commercial productivity will result within both transportation communities.

John J. Mackey
Chairman & CEO

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Guiding You Through the Legal Maze.℠

Legal Framework

for the Implementation of

EDR Technology

Dated: June 5, 2000

One Boca Place
Suite 324 Atrium, PMB #1070
2255 Glades Road
Boca Raton, Florida 33431

Objective

The legal objective is to provide a workable framework for the use of EDR technology that balances the following principles:

- We are a people of choices and freedoms;
- The underlying constitutional protections (such as freedom from unreasonable searches and seizures, Fifth Amendment rights against self-incrimination, privacy expectations, and due process safeguards) must be respected; and
- The objective of the implementation of EDR technology will be to save lives.

Model

1. **THE OWNER OF THE VEHICLE MAKES THE DECISION TO INSTALL THE EDR.**

   a. **Mass Transit/ "Common Carrier"** – regulatory agency decision

   b. **Commercial/Fleet Vehicle** – the company decides and negotiates its decision with its employees

   c. **Municipal Vehicle-** municipality decides and negotiates its decision with its drivers

   d. **Independent Trucker-** driver decides

   e. **Personal Vehicle-** personal choice (An exception may exist if there is court ordered installation of an EDR for a chronic traffic offender, after due process proceedings.)

2. **EDR DATA IS TRANSMITTED TO AN INDEPENDENT AGENCY WHICH COLLECTS DATA AS TO CLASS OF VEHICLE, SUCH AS AIRPLANE OR MOTOR VEHICLE.**

   a. Airplane information to be collected by the Flight Operations Quality Assurance (FOQA).

   b. Motor vehicle information to be collected by an entity to be determined

   c. Vessel information to be collected by an entity to be determined.

3. **EDR DATA IS TO BE IDENTIFIED BY VEHICLE IDENTIFICATION NUMBER (VIN #) OR VESSEL NUMBER.**

4. **THE EDR DATA IS OWNED BY THE OWNER OF THE VEHICLE.**

   a. The data in its cumulative form may be used by the independent agency or may be released in its cumulative form to interested entities.

   b. The data **IS PRIVILEGED IN A CIVIL PROCEEDING AND THE PRIVILEGE MAY BE WAIVED BY THE OWNER OF THE PRIVILEGE** (The privileges may be absolute or qualified depending upon the situation)

   c. The data **IS PROTECTED IN A CRIMINAL PROCEEDING AND THE CONSTITUTIONAL PROTECTIONS MAY ONLY BE WAIVED BY THE ACCUSED.** (The Fifth Amendment right against self-incrimination is absolutely preserved. Immunity may be granted consistent with prosecutorial guidelines).

5. **INSURANCE COMPANIES/ CAR MANUFACTURERS MAY USE THE DATA COLLECTED IN THE AGGREGATE.**

The owner of the vehicle may elect to release his or her information to its insurance company. The marketplace factors of the personal choices of owners/drivers would decide participation. For example, an insurance discount could be offered to a vehicle owner who elects to install an EDR in his or her vehicle.

Plan

NHTSA/ Ford - Advanced Restraints Crash Study (ARCS)
2000 Taurus/Sable

ARCS PROGRAM	NOTES
JOINT STUDY OBJECTIVES: 1. Review **system** (EMR, pretension, stage1, stage2) **operation** (like timing, thresholds, use) in terms of real-world **system inputs** (like crash severity, crash mode, delta-t). E.g., review driver stature by seat track switch & EMR use. 2. Review feasibility & utility of EDR data retrieval.	• Subsequent study of moderate+ (MAIS 2-5) injuries and crash pulse data relationships will wait the availability of a larger sample. • No injury risk or effectiveness rates.
COLLECT 100 SCI In-depth Investigations: **NCSA** = SCI in-depth reports (EES, crash, injuries) **Ford** = EDR data retrieval & reporting Technology support & training for SCI teams **Joint** = Program/ case/ technology review meetings	Three SCI teams & select NASS teams SCI download hex dump (or X module)
NOTIFICATIONS NASS team – case selections (& state FARS analysts) SCI teams – local network contacts Other – law enforcement contacts, NHTSA regions, etc.	Using current SCI notification practice
EDR DATA RETRIEVAL Teams **a)** Locate veh./'owner' & get permission **b)** Download & send hexadecimal data to Ford Ford **c)** Prepares 'public' EDR data report for Team. Jointly **d)** Review SCI field and EDR results (& process)	
CLINICAL ANALYSIS: • Group similar cases and compare with broadly similar current-generation cases from NASS/CDS or SCI. • Review restraint system operation in terms of crash parameters (system inputs).	• Not a 'proper' statistical analysis. • No direct vehicle XYZ 'with' & 'without' comparison.
SCHEDULE: Jan 12 – SDA & SCI outline study Feb 16 - NHTSA-R&D / ASO Management commitment Feb 11+ Develop field program protocol /training + Develop download tool & reporting process ar 24 Training session with NHTSA-SCI Apr-Jun Initial Joint case & technology review	 Done Done Done Done TBD

June 7th NHTSA EDR Working Group Meeting
2000

Five Categories of Data Elements (DCX proposal)

A. Restraint System Status
B*. Vehicle System Status
C*. Driver Controls
D*. Crash Pulse Information
E*. Other-Location, Time, Date, ACN, Environmental Conditions

* = No Agreement

<u>Numbered items are from List in Minutes of the October NHTSA Working Group meeting.</u>

1. Restraint System Usage (bags, belts, other)
2*. VIN & EDR ID
3*. Driver Controls (Brakes, accelerator, etc.)
4*. Vehicle Speed
5*. Crash Pulse Information
6*. Location, Time, Date
7*. Automatic Collision Notification (ACN) Data Record sent to Telematics Provider
8*. Environmental Conditions

E[illegible]t Data Recorder Summary 6-Jun-00 Pr[illegible]nary Information for Discussion Purposes Only

Qu[illegible]ion:

Do you store the data element or plan to store the data element?

	Data Item	NHTSA EDR Working Group	Use of data. Why record data?	GM	Ford	DCX	Honda	VW	Toyota
	Application (Numbered items 1-8 and bold items are from NHTSA Working Group List October 1999)	TBD-Final Fact Finding Report due early 2001	From NHTSA Working Group List-use data to improve: Accident Reconstruction, Emergency Response, Biomechanics Research, Highway Design, Threshold, Crash Causation	Started MY1999 with phase-in through MY2004. After MY2004 may add more data elements.	Internal Fleet only-for Accident Research	To be Determined	To be Determined		
	Activation of EDR Function	Frontal Airbag Deployment		Frontal-"Algorithm Enable" started by "Near Deployment" predetermined Delta V.	Frontal-100 msec prior to start of recorded crash pulse.	Pyrotechnic Deployment-any due to Front, Side, Rear Impact	Frontal "Algorithm Enable" started by "Near Deployment"		
A	**1. Restraint System Usage (airbags, belts, other)**	Yes-details determined by OEM	Accident Reconstruction, Biomechanics Research	Yes	Yes	Yes	Yes		
A	Airbag Type Deployed (i.e. Dual Stage)	Yes	Accident Reconstruction, Biomechanics Research	Yes	Yes	Yes	Yes		
A	Ignition Cycle Counter		Accident Reconstruction	Yes	Yes	Yes	Yes		
A	Seat Belt status for front occupants (with buckle switch inputs)	Yes	Accident Reconstruction, Biomechanics Research	Yes	Yes	Yes	Yes		
A	Occupant Sensing Status	Yes	Accident Reconstruction, Biomechanics Research	Yes	Yes	Yes	Yes, if applied		
A	Airbag Disable switch status	Yes	Accident Reconstruction	Yes	Yes	Yes	Yes, recorded in manual cut off SW itself		
A	Airbag warning lamp status	Yes	Accident Reconstruction	Yes	Yes	Yes	Yes		
A	System Voltage		Accident Reconstruction	Yes	Yes	Yes	No		
B	**Vehicle System Status**	Yes	Accident Reconstruction	Yes		Yes	No		
B	2. VIN & EDR ID	Yes	Accident Reconstruction	Yes		Yes	No		
B	Vehicle Mileage		Accident Reconstruction	Yes		Yes	No		
B	Engine Lamp Status		Accident Reconstruction	Yes		Yes	No		
C	**3. Driver Controls (Brakes, accelerator, etc.)**	Yes	Accident Reconstruction, Crash Causation	Yes	No	To be determined	No		
C	Cruise Control On/Off/Engaged Status	Yes	Accident Reconstruction, Crash Causation		No	To be determined	No		
C	Engine RPM	Yes	Accident Reconstruction, Crash Causation	Yes, 5 sec. Before	No	To be determined	No		
C	Throttle Position	Yes	Accident Reconstruction, Crash Causation	Yes, 5 sec. Before	No	To be determined	No		

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	Data Item	NHTSA EDR Working Group	Use of data. Why record data?	GM	Ford	DCX	Honda	VW	Toyota
C	Brake Applied	Yes	Accident Reconstruction, Crash Causation	Yes, 5 sec. Before	No	To be determined	No		
C	ABS Activated	Yes	Accident Reconstruction, Crash Causation	Yes, 5 sec. Before	No	To be determined	No		
C	4. Vehicle Speed	Yes	Accident Reconstruction, Crash Causation	Yes, 5 sec. Before	No	To be determined	No		
C	Adaptive Cruise Control and other driver assitance systems		Accident Reconstruction, Crash Causation			To be determined	No		
C	Electronic Stability Program (ESP)		Accident Reconstruction, Crash Causation			To be determined	No		
D	5. Crash Pulse Information	delta V, deceleration, angular rates	Accident Reconstruction, Emergency Response, Biomechanics Research, Threshold	Calculated (from decel. Pulse) Delta Velocity at 10ms intervals	Actual deceleration pulse at 1ms intervals	To be determined	Partial delta velocity		
E	6. Location, Time, Date-likely available from Telematics system, if equipped	Yes	Highway Design, Accident Reconstruction	Possible in future after MY2004	No	To be determined	No		
E	7. Automatic Collision Notification (ACN) Data Record sent to Telematics Provider- Time, Date, Location, Number of Occupants	Yes	Emergency Response	Possible in future after MY2004	No	To be determined	No		
E	8. Environmental Conditions	Yes	Emergency Response, Highway Design	Possible in future after MY2004	No	To be determined	No		

The Dallas Morning News

View Related Topics

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SECTION: NEWS; Pg. 1A

LENGTH: 1157 words

HEADLINE: Watching your driving Little-known 'black-box' technology on cars helps diagnose accidents, determine liability

SOURCE: Staff Writer of The Dallas Morning News

BYLINE: Terry Box

BODY:

Someday in the next couple of years, Dallas traffic investigators may arrive at accidents armed mainly with a small box.

They will plug a cable from their "data retriever" box into the wrecked car's computer, download some information and head back to the office to analyze it.

Included will be some key pieces of crash data: the vehicle's speed at the time of the accident, the position of the throttle, when the brakes were applied and whether the driver was wearing a seatbelt.

If that is more information than some Dallas drivers want shared with authorities and insurance companies, their concerns may be a little late. The technology is not only available - it's in use and is being marketed.

Most motorists, though, probably aren't aware of it. For years, cars' computers have monitored basic crash-related data as part of their airbag systems. But it has been only in the last few years that some car computers have begun storing the data.

As a result, the information is more accessible than ever.

Thousands of 2000 model General Motors and Ford vehicles are equipped with computers that record "crash-data" numbers, and a company in Santa Barbara, Calif., began selling a $ 2,500 device in March that should enable investigators to easily gather them.

"We're in talks with the California Highway Patrol now," said Don Gilman, business unit manager of Vetronix Corp. in Santa Barbara, which manufactures the Crash Data Retrieval device.

Safety sells, and the primary purpose of the technology is to provide automotive engineers and designers with real-world crash data. That, in turn, should lead to improvements in vehicles' structural and passenger-restraint systems.

"When you start putting seat sensors in cars that slow down or alter how an airbag is deployed, when you multiply the complexity of how an airbag operates, you really want to validate that it all works," said Phil asletine, president of the Automotive Coalition for Traffic Safety in Arlington, Va.

Storage the key

Over the last decade, cars' onboard computers have become increasingly sophisticated. Though they primarily control a vehicle's engine and transmission, computers perform thousands of other tasks as well.

Most measure speed, brakes and the force of a collision. All that was needed to create a de facto "black box" was the capacity to store those data, auto industry officials say.

Three years ago, the National Transportation Safety Board urged automakers to begin collecting data from their crash-related devices.

"There's no such thing on a car as a "black box,' " said Jon Harmon, Ford's technology public-affairs manager. "It's just extra memory in the car's computer. There theoretically has been the capability for some time to store that data. But up to now, we just hadn't set it up that way."

GM, which has been a leader in the effort, first put enhanced "event data recorders" on thousands of rental Cadillacs in 1998, said Terry Radigan, a GM spokesman.

This year, thousands more mainstream vehicles got the extra computer capacity, including all 2000 model Chevrolet Cavaliers and Pontiac Sunfires, Chevrolet Malibus, Impalas and Monte Carlos, the Chevrolet Venture, Pontiac Montana and Oldsmobile Silhouette minivans, and the Oldsmobile Alero and Pontiac Grand Am midsize sedans.

ord is providing similar computer capacity in its 2000 model Ford Taurus and Mercury Sable midsize sedans. Over the next year or two, Ford Motor Co. and the National Highway Traffic Safety Administration plan - with the owners' permission - to analyze data from 100 crashes involving the cars.

Data from the enhanced recorders could show, for example, that a driver was traveling at 33 mph on impact, had his foot on the brake and off the accelerator, was wearing a seatbelt and the point at which the airbag deployed.

It could also theoretically indicate - perhaps to the chagrin of an injured motorist seeking a settlement - that the driver was exceeding the speed limit, was a little slow to hit the brakes and wasn't wearing a seatbelt.

Lawsuit fodder

Data from vehicles' computers have been used in litigation for years. Even before computers began storing the data, plaintiffs' attorneys were hiring engineers to retrieve basic airbag and seatbelt information from a wrecked vehicle's computer - often a difficult task.

With the new data retrieval devices, the task should become much easier, experts say.

"It's interesting," said Windle Turley, a high-profile personal-injury lawyer in Dallas. "Each year, they add data. But so far, I can't say it has been pivotal in a case. Most of the time, it has been supportive of the case our accident reconstructionist had outlined."

Mr. Turley said he was unaware that Vetronix was selling a data retrieval device to the public. "It's good, and we need to keep moving in this direction."

Automakers also acknowledge that the data could be useful in defending themselves against product-related lawsuits.

Crash research "is the main reason for this," said Mr. Radigan of GM. "But I think it would be a tough statement to make that the sole reason we did it was to learn more about accidents."

GM, for example, was able to prevail in a lawsuit brought by the survivors of former pro football player Jerome Brown. Mr. Brown died in 1992 when his high-performance ZR-1 Corvette hit a tree.

the lawsuit, Mr. Brown's survivors contended that the Corvette's airbag deployed when the car hit a pothole, causing Mr. Brown to lose control of it. But airbag data stored in the car's computer - a forerunner of the more sophisticated system now in use - showed that the airbag deployed on impact, as it was designed to do.

GM maintains that the crash data belong to the owner of the car. Information about the crash-data capabilities can be found in owners' manuals. So far, a few hundred owners have contacted the company after an accident and asked that the crash data from their cars be downloaded, said Mr. Radigan.

"Any time we get a chance, we will dispatch someone to download the information," he said. "We're anxious to learn more about it."

Although GM maintains that the crash data are basically private information - Ford has not taken an official position yet - Mr. Gilman of Vetronix Corp. and others expect it to become more public shortly.

Already, judges have ordered crash data during evidentiary hearings. Some police departments view it as impounded evidence when a car involved in an accident is suspected of causing the accident, Mr. Gilman said.

"There are many invasions of privacy now," he said. "Your bags are searched at the airport. If an officer looks through the window of your car and sees you drinking a beer, he is going to stop you. If they see you not wearing a seatbelt, you're going to get a ticket.

"This is a gray area that in two or three years will be resolved one way or the other," he said.

Safety experts cautiously open automotive black box

HARRY STOFFER <mailto:hstoffer@crain.com>
Staff Reporter

WASHINGTON -- Automotive safety researchers, cautiously avoiding the inflammatory term "black box," plan to download information from 100 wrecked vehicles this year to demonstrate the usefulness of data recorders in cars and trucks.

"We're here to look at solving the (safety) issues, not deciding who's at fault in these crashes," said Ernie Grush, Ford Motor Co.'s manager of safety data analysis.

By getting owners' permission to collect information and keeping its sources anonymous, researchers will steer clear of the privacy and liability arguments surrounding so-called black boxes in cars and trucks, Grush said.

Privacy advocates fear the data could be used, for example, to charge drivers with speeding or to assign blame for crashes. They also say principles of privacy rights are at stake.

On the other hand, researchers say the data are needed to improve auto safety.

TAILORING AIRBAGS

The National Highway Traffic Safety Administration will be investigating the selected crashes first to evaluate the performance of advanced airbags, which are capable of tailoring deployments to different occupants and crash conditions.

Then automakers will collect electronic readings from the airbag modules about vehicle speed, rate of deceleration and impact forces.

Such information ultimately could lead to vehicle safety improvements. "Our sensor designers need all the help they can get," Grush said.

NHTSA officials confirmed their involvement in the research but declined to discuss details.

Grush expects many of the 100 examined vehicles to be 2000 Ford Tauruses and Mercury Sables because their advanced restraint systems have data-recording capability.

Earlier disclosures that airbag modules, especially those in General Motors vehicles built since 1993, have some data-recording functions created stirs among privacy advocates.

William Safire, a columnist for The New York Times, wrote last year that use of the devices is a "slippery slope of secret surveillance."

SAFETY VS. PRIVACY

The National Transportation Safety Board, however, since 1997 has had a standing recommendation that NHTSA, in cooperation with vehicle manufacturers, collect better information about crashes using "current or augmented crash sensing and recording devices."

In 1998 NHTSA established a panel of government and industry officials to consider requirements for event data recorder technology and to study the privacy and legal issues. It has not yet issued its findings.

Last month, the National Transportation Safety Board held a symposium on data collection and the law, covering all forms of transportation.

Board chairman Jim Hall said then, "While every individual's right to privacy must be respected and protected as much as possible, should that be the determining factor when we make decisions on public-safety issues?"

Chicago Tribune

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Y FOR SAVVIER AUTOMOTIVE 'BLACK BOX'

ֽ͵pecial to the Tribune.

can keep tabs on what happens when motor vehicles crash is growing more
ntinues in the auto industry on whether every new car should have one.

recently that it had developed a new sensor version of the accident data
r than the old recorders but harvests more information. The new Delphi
Racing League vehicles and by Formula One teams this year, said Kathryn

its debut at this year's Indianapolis 500, is 40 percent lighter and nearly half
rd critical information before, during and after a crash, said Oldham, who
e first generation of ADR led to designs that have improved the protection of

s around the car, the ADR2 can offer accident investigators a remarkably clear
ash sequence, says Glen Gray, Delphi's motorsports engineering manager.

osition and steering angle the instant the vehicle crashes. It comes with
vehicle's deceleration, Gray says. The greater the deceleration, the more

gy also will be used in a computer-powered chassis control system that uses
keep a vehicle stable on bad roads or in treacherous conditions.

re data from multiple sensors indicates how sophisticated the black-box technology could become in the family sedan.

General Motors has used the original ADR technology to learn more about air-bag deployment in crashes, and since the mid-1990s has sold more than 20 million vehicles with such "event data recorders." Information explaining the workings of the recorder, which cannot be disconnected or turned off, is included in the owner's manuals, notes GM spokesman Terry Rhadigan.

GM plans to install the recorders on more cars but has not decided whether to use the more sophisticated technology, Rhadigan added.

Other automakers have been reluctant to follow GM's lead.

Spokeswoman Sara Tachio said Ford Motor Co. recently agreed to give the National Highway Transportation Safety Administration the tools to retrieve data from wrecked new Fords. The information will be used for a study of advanced crash protection systems, Tachio said.

NHTSA has promised the data collected in the study will be sanitized of all names or other information that could identify the individuals involved in the crash, she adds.

Dave Wilkins, a DaimlerChrylser spokesman, notes that information collected from real-world crashes can be invaluable.

"It can go a very long way toward creating a better air bag," he added.

NHTSA has not taken an official position on whether to require a sensing and diagnostic module that could record pre- and post-crash data on every vehicle sold in the U.S.

The National Transportation Safety Board, which investigates air, rail and highway crashes, has recommended NHTSA's regulators make the black boxes standard in a vehicles. The joint government-industry task force studying the issue, the Motor Vehicle Research Administration Committee, is reviewing proposals and a final recommendation isn't expected until late this year, says Mike Aberlich, a spokesman for DaimlerChrysler, who keeps track of safety-related issues.

The basic technology needed to record crash information is part of every vehicle with an air bag, notes Aberlich. The more fundamental question is what should be done with the information.

TELLTALE TECH UNCOVERING THAT OLD BLACK-BOX MAGIC

By Matt Lake
New York Times News Service
May 21, 2000

Before the mid-1950s, commercial passenger aircraft looked much like the one that parted Ingrid Bergman and Humphrey Bogart at the end of "Casablanca"--propellers on each wing, and they flew at what we would now consider a leisurely pace. It was not until the British company de Havilland leveraged wartime research on jet propulsion into a commercial jetliner called the Comet that rapid air transport became feasible.

The Comet was able to fly faster and higher than propeller planes, and it was put into service three years before any other company could produce a competing jet. But the Comet suffered several high-profile crashes in 1953 and '54, which gave rise to doubts about the future of jet travel. Before the jet age could begin in earnest, the safety of jet aircraft had to be proved.

The problem was a lack of evidence about what had caused the Comet accidents. With no witnesses, scanty evidence about what had occurred and most of the wreckage lost at sea, the post-crash analyses were sketchy. Eventually, some hard evidence turned up revealing that pressure changes had weakened the window structure--but not before frustrated aeronautical organizations across the world had hypothesized at length on the basis of little hard data.

One of the scientists involved, Dr. David Warren, devised a plan that he hoped would lessen such frustration. Warren, a fuel chemist at the Aeronautical Research Laboratories in Australia, proposed that recording devices be put in the cockpit to capture information. Such devices are now in all commercial aircraft: the flight data recorder and the cockpit voice recorder.

Based on Warren's 1954 report, the Australian laboratory produced a prototype called the flight memory recorder, which is on display in a science museum in Melbourne. The device recorded four hours of pilot conversation and eight instrument readings by engraving data onto a loop of wire, a design that soon gave way to magnetic tape loops. The concept caught the interest of British aviation authorities in the late 1950s, and aviation agencies across the world had begun to mandate their use by the 1960s.

The devices have changed in a number of ways, but the basic idea remains the same. When the recorder reaches the end of the tape loop, it records over the older data, providing a constantly updated record for use in analyzing what happened during a flight.

In the 1970s, the de facto standard for storing such data was in digital format on tape. In the early 1990s, new designs were introduced using solid-state flash memory; the new designs can store 700 different flight parameters, enough to cover the huge number of controls and systems in modern aircraft. Solid-state recorders are in the minority, but they are likely to become much more common in the next few years.

The purpose of flight data and cockpit voice recorders is to provide air transport safety agencies with enough information to pin down the reasons for accidents and develop safety procedures to prevent them. (The data are also sometimes downloaded onto portable computers after routine flights for airlines to use in establishing the normal flight characteristics of each plane.)

Every jet is loaded with sensors that measure things such as the position of engine controls, the altitude, the amount of thrust for all engines and the temperature and pressure in various parts of the aircraft, as well as the yaw (left and right motion), pitch (up and down motion) and roll (motion around the longitudinal axis). That kind of information--and a whole lot more--ends up on the flight data recorder.

Cockpit voice recorders capture not only voices but also engine noise, alarms and the sounds of the deployment of landing gear, flaps and so on. The machine noise often proves invaluable in analyzing accidents.

Because flight data recorders are intended mainly for post-crash analyses, the boxes are in the most crash-resistant part of the airplane, the tail. The boxes are also robust in their own right--the parts where data are stored are usually made of steel or titanium so they can withstand impact. They also contain heat shields made of polymers (heat-resistant wax).

After a crash, the recorders go to the aviation safety authority of the country where the accident took place. In the U.S., that is the National Transportation Safety Board. There, computers download the information stored on the data recorder and use it to create reconstruct the flight. These simulations can include all the cockpit meters and controls and three-dimensional computer models of the aircraft.

The safety board makes data from flight recorders available to the airline and aircraft and engine manufacturers. What the analyses find out can lead to changes in manufacturing and maintenance for that type of aircraft.

But flight data recording is not only for post-disaster analyses. Airlines can use information about specific aircraft to help with maintenance and other issues. A 737 that has been shown by the data recorders to be more fuel-efficient than the norm, for example, can carry less fuel and fly more cheaply.

Since the data recorder is not readily accessible to technicians in the field, many aircraft have secondary recorders stored near the cockpit. Known as quick-access recorders, they use tape or optical discs to store flight data for routine checks.

In the U.S., commercial aircraft must carry separate flight data recorders and cockpit voice recorders. Data recorders must be able to hold the last 25 hours of instrument readings and must be able to handle a minimum number of sensor readings. That minimum varies from 17 to 88, depending on the aircraft.

oice recorders must retain the most recent 30 minutes of sound on four channels--three channels for crew microphones and one for a fourth microphone that picks up ambient noise. (Newer aircraft often have only two crew members in the cockpit so the microphone that used to be reserved for the flight engineer usually records intercom announcements.)

Solid-state recorders have expanded the scope of the devices, and regulations are catching up with the technology. Data-and-voice recorders are becoming so common that the safety board has recommended that by 2005, some kinds of aircraft should be required to have two: one in the tail, the other near the cockpit.

And digital sound recorders can hold more than tape loops, so by 2003, new airplanes will have to have sound recorders with a capacity of 120 minutes, in line with European standards.